

CLAIMS

1. A control method of an internal combustion engine, for controlling an internal EGR rate by changing an opening timing and a closing timing of an intake valve and an exhaust valve
5 to control an overlap period and a non-overlap period, said method comprising:

controlling a throttle position of a throttle valve in accordance with an increase of a required amount of an engine output, in a first load range of the internal combustion engine
10 which covers from a no-load to a load in one of a low-load range and a middle-load range, so as to open the throttle valve from an idle opening degree to one of a full opening degree and an almost full opened degree at the load;

controlling the throttle position to one of the full opening
15 degree and the almost full opened degree, in a second load range that is over the load;

controlling the engine output by controlling the overlap period and the non-overlap period in accordance with the required amount, in an entire load range; and

20 controlling the non-overlap period to obtain a maximum internal EGR rate from a maximum non-overlap period at the load.

2. The method according to claim 1, further comprising:

25 controlling the throttle position to increase an opening degree of the throttle valve in accordance with the increase

of the required amount, over the entire load range during warming-up of the internal combustion engine; and

controlling a valve operation characteristic so as not to form the non-overlap period over the entire load range during warming-up.

3. The method according to claim 1, further comprising:

controlling a valve operation characteristic to increase the internal EGR rate in accordance with the increase of the required amount, in the first load range; and

controlling the valve operation characteristic to decrease the internal EGR rate in accordance with the increase of the required amount, in the second load range.

4. The method according to claim 1, further comprising:

controlling a valve operation characteristic including a maximum lift amount of the intake valve; and

controlling the valve operation characteristic to decrease the maximum lift amount in accordance with one of a decrease of the overlap period, an increase of the non-overlap period and an increase of the internal EGR rate.

5. The method according to claim 4, further comprising:

controlling the valve operation characteristic so that an effective overlap period and an effective non-overlap period become one of zero and almost zero at one of a maximum overlap

period and a minimum internal EGR rate.

6. A control method of an internal combustion engine, for controlling an internal EGR rate by controlling a valve operation characteristic, comprising:

controlling a throttle position of a throttle valve in accordance with an increase of a required amount of an engine output, in a first load range of the internal combustion engine from a no-load to a load in one of a low-load range and a middle-load range, so as to open the throttle valve from an idle opening degree to at least an almost full opened degree at the load;

controlling the throttle position to at least the almost full opened degree, in a second load range that is over the load;

controlling the internal EGR rate and the engine output by controlling the valve operation characteristic in accordance with the required amount, in an entire load range; and

controlling the valve operation characteristic to obtain the maximum internal EGR rate at the load.

7. The method according to claim 6, further comprising:

controlling the throttle position to increase an opening degree of the throttle valve in accordance with the increase of the required amount, in the entire load range, during warming-up of the internal combustion engine; and

controlling the valve operation characteristic so that the internal EGR rate is substantially minimized over the entire load range during the warming-up.

5 8. The method according to claim 6, further comprising:

controlling the valve operation characteristic to increase the internal EGR rate in accordance with the increase of the required amount, in the first load range; and

10 controlling the valve operation characteristic to decrease the internal EGR rate in accordance with the increase of the required amount, in the second load range.

15 9. The method according to claim 6, wherein the valve operation characteristic includes a maximum lift amount of the intake valve, further comprising:

controlling the valve operation characteristic to decrease the maximum lift amount in accordance with one of an decrease of an overlap period, an increase of a non-overlap period and an increase of the internal EGR rate.

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10. The method according to claim 9, further comprising:

controlling the valve operation characteristic so that an effective overlap period and an effective non-overlap period become one of zero and almost zero at one of a maximum overlap period and a minimum internal EGR rate.

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11. A control apparatus of an internal combustion engine, comprising:

a throttle controlling mechanism for controlling a throttle position of a throttle valve that controls an amount of intake
5 air;

a valve characteristic varying mechanism for controlling a valve characteristic including an opening timing and a closing timing of an intake valve and an exhaust valve, wherein the valve characteristic varying mechanism changes the closing
10 timing of the exhaust valve to control an overlap period and a non-overlap period, thereby controlling an internal EGR rate, and

an output setting mechanism for setting a required amount of engine output,

15 wherein the throttle controlling mechanism controls the throttle position in accordance with an increase of the required amount, in a first load range of the internal combustion engine from a no-load to a load in one of a low-load range and a middle-load range, so that the throttle valve is opened from an idle opening
20 degree to one of a full opening degree and an almost full opened degree at the load,

the throttle controlling mechanism controls the throttle position, in a second load range over the load, so that the throttle valve is opened in one of the full opening degree
25 and the almost full opened degree,

the valve characteristic varying mechanism controls the

engine output by controlling the overlap period and the non-overlap period in accordance with the required amount, in an entire load range, and

the valve characteristic varying mechanism controls the non-overlap period to obtain a maximum internal EGR rate from a maximum non-overlap period at the load.

12. The apparatus according to claim 11, wherein the throttle controlling mechanism controls the throttle position to increase an opening degree of the throttle valve in accordance with the increase of the required amount over the entire load range during warming-up of the internal combustion engine, and

the valve characteristic varying mechanism controls the valve operation characteristic so as not to form the non-overlap period over the entire load range during warming-up of the internal combustion engine.

13. The apparatus according to claim 11, wherein the valve characteristic varying mechanism controls the valve operation characteristic to increase the internal EGR rate in accordance with the increase of the required amount, in the first load range, and controls the valve operation characteristic to decrease the internal EGR rate in accordance with the increase in the required amount in the second load range.

14. The apparatus according to claim 11, wherein the valve

operation characteristic includes a maximum lift amount of the intake valve, and the valve characteristic varying mechanism controls the valve operation characteristic to decrease the maximum lift amount of the intake valve in accordance with one of an decrease of the overlap period, an increase of the non-overlap period and an increase of the internal EGR rate.

15. The apparatus according to claim 14, wherein the valve characteristic varying mechanism controls the valve operation characteristic so that an effective overlap period and an effective non-overlap period is one of zero and almost zero at one of a maximum overlap period and a minimum internal EGR rate.

16. A control apparatus of an internal combustion engine, comprising:

a throttle controlling mechanism for controlling a throttle position of a throttle valve that controls an amount of intake air;

a valve characteristic varying mechanism for controlling a valve characteristic including a closing timing of an exhaust valve, wherein the valve characteristic varying mechanism varies the valve operation characteristics to control the internal EGR rate; and

an output setting mechanism for setting a required amount of engine output,

wherein the throttle controlling mechanism controls the throttle position in accordance with an increase of the required amount, in a first load range of the internal combustion engine from a no-load to a load in one of a low-load range and a middle-load range, so that the throttle valve is opened from an idle opening degree to one of a full opening degree and an almost full opened degree at the load,

the throttle controlling mechanism controls the throttle position, in a second load range which covers a load range over the load, so that the throttle valve is opened in one of the full opening degree and the almost full opened degree,

the valve characteristic varying mechanism controls the internal EGR rate and controls the engine output by controlling the valve operation characteristic in accordance with the required amount, in an entire load range, and

the valve characteristic varying mechanism controls the valve operation characteristics to obtain the maximum internal EGR rate at the load.

17. The apparatus according to claim 16, wherein the throttle controlling mechanism controls the throttle position to increase an opening degree of the throttle valve in accordance with the increase of the required amount over the entire load range during warming-up of the internal combustion engine, and

the valve characteristic varying mechanism controls the valve operation characteristic so that the internal EGR rate

is substantially minimized over the entire load range during the warming-up.

18. The apparatus according to claim 16, wherein the valve
5 characteristic varying mechanism controls the valve operation
characteristic to increase the internal EGR rate in accordance
with the increase of the required amount, in the first load
range, and controls the valve operation characteristic to
decrease the internal EGR rate in accordance with the increase
10 in the required amount in the second load range.

19. The apparatus according to claim 16, wherein the valve
operation characteristic includes a maximum lift amount of
the intake valve, and the valve characteristic varying mechanism
15 controls the valve operation characteristic to decrease the
maximum lift amount of the intake valve in accordance with
one of an decrease of the overlap period, an increase of the
non-overlap period and an increase of the internal EGR rate.

20. The apparatus according to claim 19, wherein the valve
20 characteristic varying mechanism controls the valve operation
characteristic so that an effective overlap period and an
effective non-overlap period is one of zero and almost zero
at one of a maximum overlap period and a minimum internal EGR
25 rate.